PROCEEDINGS OF SCIENCE

NEXT

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The discovery of neutrinoless double beta decay is one of the main targets of particle physics nowadays. It would demonstrate that neutrinos are Majorana particles, which does not fit in the Standard Model as it currently stands. NEXT is an experiment aiming for such discovery. The detector, a high-pressure xenon TPC, provides two remarkable features for searching this decay: an excellent energy resolution (below 1% FWHM at $Q_{\beta\beta}$) and topological signature for background rejection. This detection technique makes it possible to reach a sensitivity to $T_{1/2}$ of $5 \cdot 10^{25}$ y with an exposure of 300 kg $\cdot$ y, competitive with the leading experiments in the field.

Neutrino Oscillation Workshop
4 - 11 September, 2016
Otranto (Lecce, Italy)

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PoS(NOW2016)071

1. Search for the neutrinoless double beta decay

Double beta decay ($\beta\beta^{2\nu}$) is a rare nuclear decay in which two neutrons decay simultaneously to two protons emitting a pair of electrons and a pair of neutrinos. It has been observed in eleven different isotopes and its half life has been measured to be in the range of 10^{19} to 10^{24} y. It is also hypothesized that a neutrinoless version of the same decay ($\beta\beta^{0\nu}$) could be possible, but only if neutrinos are Majorana particles, i.e. they are their own antiparticles. The signature of this decay is a peak at the endpoint ($Q_{\beta\beta}$) of the energy specturm of the emitted electrons. The two-neutrino mode spectrum, on the other hand, is continuous and ends at $Q_{\beta\beta}$, as the neutrinos carry away part of the energy. The lifetime of $\beta\beta^{0\nu}$, although unknown, would be much longer than that of the two-neutrino mode. Energy resolution is, thus, of paramount importance in order to separate the signal from the inherent $\beta\beta^{2\nu}$ background.

2. NEXT

NEXT will search for $\beta\beta^{0\nu}$ in ^{136}Xe using a high-pressure gas (HPXe) TPC instrumented with PMTs (for calorimetry and t_0) and SiPMs (for topological reconstruction). It will contain 100 kg of xenon enriched to 90% in ^{136}Xe at 15 bar. The ionization signal produced by the electrons is amplified with electroluminiscence. The linearity of this process helps to achieve an energy resolution close to the Fano Factor in gas (below 1% FWHM at $Q_{\beta\beta}$).

Moreover, the ability to reconstruct the topology of the events allows the rejection of radioactive backgrounds. High energy electrons scattering through the gas behave as minimum ionizing particles and transfer small amounts of energy. On the other hand, at low energies the scattering becomes harder and the density of energy deposited is much higher (*blob*). Signal events (either $\beta\beta^{2\nu}$ or $\beta\beta^{0\nu}$) are mainly two electrons, and therefore will show two *blobs*, while background events are made of single electrons and only one blob will be present (see Fig. 1).

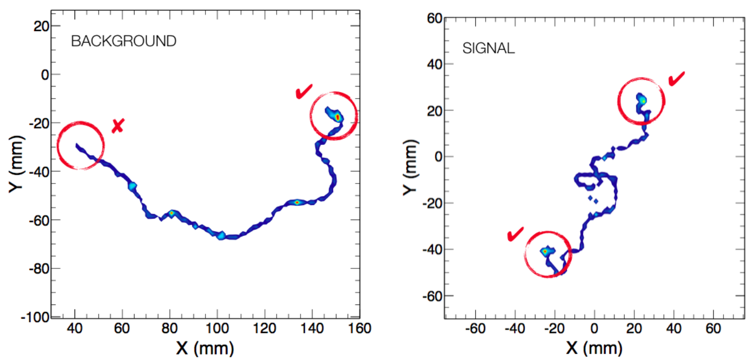

Figure 1: Representation of the different topological signatures found in Monte Carlo-simulated background (left) and signal (right) events [1].

2.1 NEXT-DEMO & NEXT-DBDM

NEXT-DEMO and **NEXT-DBDM** were two kg-scale prototypes devoted to prove the detector concept that ran simultaneously from 2009 to 2014. The energy resolution was measured with both detectors. In **NEXT-DEMO**, the 0.511 MeV ^{22}Na photopeak was reconstructed at 1.62% FWHM [2], while a resolution of 1.00% FWHM was achieved for the 0.662 MeV ^{137}Cs peak [3] in **NEXT-DBDM** (see Fig. 2). Both results extrapolate to 0.5-0.7% FWHM at $Q_{\beta\beta}$. Moreover, the rejection of background using event topology in HPXe was recently demonstrated with the former [1].

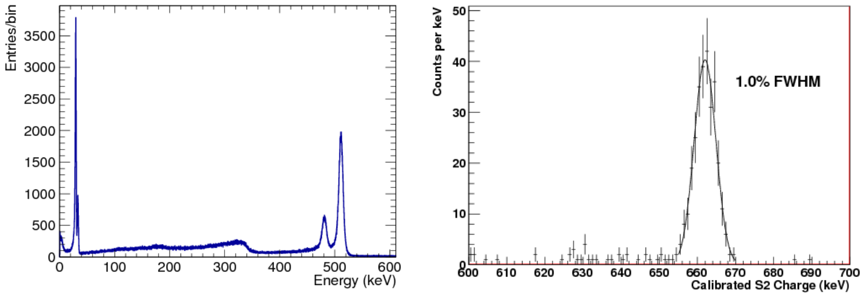

Figure 2: Energy spectra obtained with different calibration sources. The ^{22}Na spectrum in **NEXT-DEMO** (left) [2] and the ^{137}Cs one in **NEXT-DBDM** (right) [3] demonstrate the energy resolution capabilities of HPXe TPCs.

2.2 NEXT-WHITE

NEXT-WHITE is a 1:2 scale radiopure prototype operating underground at the Laboratorio Subterráneo de Canfranc (LSC). It is instrumented with 12 3-inch PMTs and 1792 SiPMs. With this detector, the collaboration aims to solve the last technological challenges, test the background model and observe the $\beta\beta^{2\nu}$ energy spectrum in order to measure the half-life of the decay.

The detector has been recently completed and it has started its underground operation at LSC. Calibration runs show that the detector is alive and the sensors behave correctly. During the following months, the detector will be completely calibrated, the energy resolution measured and the topology discrimination power assessed. Physics runs will take place during 2017 and 2018, taking data with depleted xenon for background modeling and with enriched xenon for $\beta\beta^{2\nu}$ physics.

3. The NEXT-100 detector

NEXT-100 is a 1.3 m drift-length TPC instrumented with 60 3-inch PMTs and nearly 8000 SiPMs placed in a 1cm-pitch grid. It is scheduled to begin its operation during 2019. The reduction of background rate is of the utmost importance for this detector as it affects sensitivity to $\beta\beta^{0\nu}$ directly. Hence, all detector components have been radio-screened at LSC. The leading contributions to the background in the region of interest come from ^{214}Bi and ^{208}Tl in the PMTs and the kapton dice boards holding the SiPMs. A conservative upper limit has been placed for the unmeasured components. Combining this data provides an overall upper limit to the background rate of $4\cdot 10^{-4}$ c/keV/kg/y. This translates to a sensitivity to $T_{1/2}$ of $5\cdot 10^{25}$ y at 90% CL [4] (see Fig. 3).

4. Scalability

The race for the discovery of $\beta\beta^{0\nu}$ is heading now towards tonne-scale detectors and reducing background rates is a major milestone for all of them. The detector concept of NEXT is very suit-

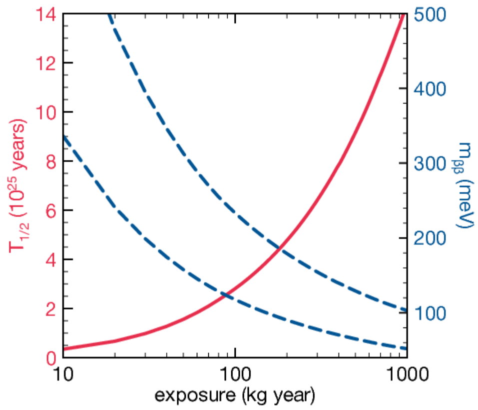

Figure 3: Sensitivity of **NEXT-100** at 90% CL to $T_{1/2}$ (solid curve) and $m_{\beta\beta}$ (dashed curves) as a function of exposure assuming a background rate of $4 \cdot 10^{-4}$ c/keV/kg/y [4].

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able for such scaling as TPCs extrapolate very well to large masses. In order to achieve an almost background-free detector, several strategies are being studied. For instance, reducing the SiPMs' pitch or introducing gas mixtures [5] improve track reconstruction and therefore background rejection. On the other hand, replacing the PMTs by large-area SiPMs would reduce the background rate significatively.

Acknowledgements

The NEXT Collaboration acknowledges support from the following agencies and institutions: the European Research Council (ERC) under the Advanced Grant 339787-NEXT; the Ministerio de Economía y Competitividad of Spain and FEDER under grants CONSOLIDER-Ingenio 2010 CSD2008-0037 (CUP), FIS2014-53371-C04 and the Severo Ochoa Program SEV-2014-0398; GVA under grant PROMETEO/2016/120.

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